2.0 CONFIGURATION MANAGEMENT BASELINE

This CM baseline describes the current version status, version history, model development policy, available documentation, and configuration management policies, procedures, guidelines, and support functions in place for RADGUNS. Much of the historical data relevant to original and incremental development is documented in the CMS included in ASP-II. Procedural CM policy has, in the past, been non-existent, although the code appears to be well controlled by the model developer. A CCB was formed May 25, 1995 to add structure to configuration control functions. Preliminary procedures are being implemented to regulate and standardize CM for the RADGUNS model. RADGUNS is currently at version 2.0.

2.1 MODEL DESCRIPTION

RADGUNS is a one-on-one simulation, that includes a weapon system, operators, target (radar cross section, presented and vulnerable areas), flight paths, environment (clutter and multipath), and electronic countermeasures. Components of each weapon system including a search radar, a radar or optical tracking system, a set of antiaircraft guns, a fire-control computer/servo system to aim the guns, and a crew to operate the system are modeled at either the subsystem or circuit level. The models are deterministic, or transfer function type, rather than stochastic (probabilistic). Pulse-by-pulse radar receiver models process the returns from the target, including multipath effects, ground clutter, and signals from jammers. Probabilities of hit and kill are calculated using distribution theory and presented and vulnerable areas of the target.

RADGUNS simulates detection, tracking, and shooting performance of over 30 different AAA systems (see Table 2-1) during engagements with airborne targets. It is typically used to evaluate the effectiveness of AAA systems against aircraft targets penetrating hostile airspace, but it can also be used to evaluate the effectiveness of different target characteristics (radar cross section, maneuvers, use of electronic countermeasures, etc.) against those systems.

TABLE 2-1. Weapons Systems Modeled in *RADGUNS.*

Weapon System Name
PKM 7.62-mm machine gun (tripod-mounted)
NSV 12.7-mm
ZPU-1 14.5-mm
ZGU-1 14.5-mm
ZPU-2 14.5-mm
ZPU-4 14.5-mm
Drum Tilt B/14.5-mm
Vulcan 20-mm Gatling gun
ZU-23 23-mm
ZSU-23-4 23-mm
25-mm Oerlikon KBB
2S6 30-mm (excluding missiles)
30-mm Czech M53/70

TABLE 2-1. Weapons Systems Modeled in *RADGUNS*. (Contd.)

Weapon System Name
Bass Tilt/30-mm AK-630 naval Gatling gun
Bass Tilt/30-mm AK-630M1-2 naval Gatling gun
CADS-1 naval 30-mm Gatling gun (FOR TEST ONLY)
Superfledermaus/Oerlikon GDF-003 35-mm
Skyguard/Oerlikon GDF-003 35-mm
Skyguard with Eagle/Oerlikon GDF-003 35-mm
Flycatcher/Oerlikon GDF-003 35-mm
M1939 former Soviet 37-mm or Type 55 Chinese land-based 37-mm
V-11-M 37-mm naval
Superfledermaus/Bofors L/70 40-mm
Superfledermaus with Eagle/Bofors L/70 40-mm
Skyguard/Bofors L/70 40-mm
Skyguard with Eagle/Bofors L/70 40-mm
Flycatcher/Bofors L/70 40-mm
Fire Can/57-mm S-60
Flapwheel/57-mm S-60
ZSU-57-2 57-mm
Bass Tilt/76-mm AK-176 naval
Oto Melara Otomatic 76-mm land-based
Fire Can/85-mm KS-12
Fire Can/100-mm KS-19M2
Flapwhell/100-mm KS-19M2
Kite Screech/100-mm AK-100 naval
Kite Screech/130-mm/67 naval

Note: Several additional acquisition radars are modeled.

Targets modeled in *RADGUNS* via RCS, presented, and vulnerable areas can include fixed-wing aircraft, rotary-wing aircraft, missiles, and unmanned aerial vehicles (UAVs). Ten built-in flight path types may be selected and controlled by user-defined input parameters. In addition, flight paths produced by Blue Max II may be used as inputs to *RADGUNS*. *RADGUNS* can simulate target detection (via threshold detection or probability of detection models) and plot either maximum target detection ranges vs. altitude or probability-of-detection curves. The model is capable of recording tracking errors in 3 dimensions and break locks due to excessive angular velocity or jamming. Parameters such as target RCS, target power, clutter power, and various receiver signals can be plotted graphically. Shooting performance includes the range at which the target is first vulnerable to fire from the weapon system. Other parameters computed are: single-intercept, burst, and cumulative probability of hit and kill; expected number of hits; and miss distances. The model is briefly described in Table 2-2.

TABLE 2-2. *RADGUNS* Description.

Title	***RADGUNS* —RAdar-Directed GUN system Simulation**
Model Type	Analysis
Proponent	National Ground Intelligence Center (formerly the US Army Foreign Science and Technology Center), IANG-SRA, 220 Seventh Street NE, Charlottesville, VA 22901-5396
Point-of-Contact	Mr. Dwight FitzSimons, VOICE: (804) 980-7838 or DSN 934-7838; UNCLAS FAX: (804) 980-7699
Purpose	*RADGUNS* is used to evaluate the effectiveness of AAA systems against penetrating aerial targets. It can also evaluate the effectiveness of different airborne target characteristics (radar cross section, maneuvers, use of electronic countermeasures, etc.) against a specific AAA system.
Domain	Land, naval, and air
Span	Individual
Environment	Analytic clutter and multipath models are implemented. Two sets of models are employed, parameterized either by land/sea characteristics or by clutter RCS/area and multipath coefficient. Terrain modeling is limited to a single user-defined hill.
Force Composition	One AAA system versus one penetrating airborne target. *RADGUNS* models the full AAA system engagement, including search and track radars, optic systems, guns, fire-control computer, operators, environment, electronic countermeasures, and target aircraft. Current land-based models include 7, 12.7, 14.5, 20, 23, 25, 30, 35, 37, 40, 57, 60, 76, 85, 100, and 130 mm AAA systems. Target models include 20 aircraft or missiles, and one user-defined target.
Scope of Conflict	Conventional radar or optical-directed AAA.
Mission Area	One-versus-one AAA engagement.
Level of Detail of Processes and Entities	Single AAA system against a single airborne target. Target tracking is based on pulse-by-pulse radar receiver model processing the returns of the target (including multipath and ground clutter). Attrition of airborne target is probability of kill using 6- and 26-view target singly-vulnerable areas. Single-intercept, burst, and cumulative probability of hit and kill are calculated.
Human Participation	Not required, model not interruptible after initiation.
Time Processing	Dynamic, time step
Sidedness	One-sided
Limitations	Cannot simulate one-versus-many or many-versus-many encounters. Terrain modeling is limited to analytic terrain models. No reactive maneuvering against a weapon system. Chaff and flares not modeled at this time.
Planned Improvements and Modifications	Additional seeker and tracker systems, gun systems, ECM and ECCM capabilities, DMA terrain model, multiply-vulnerable area end-game model.
Input	Scenario parameters are specified in an input "parameters" file.
Model Type	Analysis
Output	Depends on simulation type and user selection. An event-by-event tabular file is generated, as are files for tabulation and plotting of simulation results. The user can also select generation of a file for 3-dimensional graphics display using the RADPIX plotting program (which calls Plot-10 IGL routines and uses a Tektronix graphics terminal (or emulator)).

TABLE 2-2. *RADGUNS* Description. (Contd.)

Title	***RADGUNS* —RAdar-Directed GUN system Simulation**
Computers (Operating Systems)	IBM 9000 (VM-CMS), VAX (VMS & UNIX), SGI (UNIX), SUN (UNIX), IBM PC (MS-DOS).
Storage	N/A
Peripherals	Printer and optional Tektronix graphics terminal.
Language	FORTRAN 77.
Documentation	*RADGUNS* Antiaircraft Artillery Simulation Version 2.0: Volume 1. User Manual (U), Volume 2. Supplement to User Manual (S), Volume 3. Methodology and Design Manual (U).
Security Classification	Code is up to SECRET, target data SECRET/NOFORN
Date Implemented	1985 (latest version: 2.0 (2/96)).
Data Base	Hard-coded in program.
CPU Time per Cycle	N/A
Data Output Analysis	N/A
Frequency of Use	Daily during course of a study.
Users	Approximately 90, including USANGIC, AFSAA/SAG, NAWCWPNS, et al.
Comments	JTCG/AS has accepted *RADGUNS* as its standard AAA model.

2.2 DEVELOPMENT HISTORY

Development of the first generation of AAA simulations at the U. S. Army Foreign Science and Technology Center (FSTC, now NGIC) began in 1975 with a model of the Soviet FLAP WHEEL radar, followed by a model of the complete ZSU-23-4 weapon system. This first-generation simulation was called HIFADS (High-Fidelity Air Defense Simulation). Tasking in 1983 for weapon lethality assessments necessitated further development of this AAA simulation capability, but close examination of HIFADS revealed a monolithic (non-modular) simulation that was considered too poorly structured to build upon. Therefore, development of the second generation of AAA simulations (*RADGUNS*) to replace HIFADS began in 1983 in the Reconnaissance, Surveillance, and Target Acquisition (RSTA) Branch (now the Systems Air Combat (SAC) Branch). The first weapon system modeled was the Soviet ZSU-23-4. This system was chosen for two reasons: 1) there was a need for lethality assessments of this system, and 2) the system could be very accurately modeled and validated due to recent exploitation efforts. There was also a need to provide a good basis upon which to build a model of its follow-on, the 2S6. Following the development of models for these two weapon systems, models were developed for the Superfledermaus and Skyguard radars and the Oerlikon 35-mm and Bofors 40-mm guns and fire control computers. These simulations used much of the same code developed for the first two systems, giving them a very similar structure but one that allowed for inclusion of functions and data constants specific to the particular system. This modular, building block approach has been sustained by the *RADGUNS* development team, which has produced simulations for 38 AAA systems.

As the program has broadened in scope and use within DoD, assistance has been elicited from other branches within NGIC and from outside agencies. The following entities have assumed roles and responsibilities with respect to development, maintenance, and distribution of *RADGUNS*. Their various responsibilities are described in Table 2-3 below.

TABLE 2-3. *RADGUNS* Key Organizations/Agency Responsibilities.

Organization/Agency	Responsibilities
NGIC/SRA Branch (IANG-SRA)	• Program Manager and Prime Developer • Establishes directions, priorities, and plans for the *RADGUNS* simulations • Develops models of AAA systems and implements (or directs the implementation of) these models in software • Coordinates simulation development, distribution, and use for all development contributors and simulation users
NGIC/Intelligence Branch (IANG-SRA)	• Overall responsibility to the Defense Intelligence Agency (DIA) for the land-based weapon systems modeled by *RADGUNS* • Provides scientific and technical (S&T) data on weapon systems, with tactics and engagement doctrine • Provides feedback on the operation and performance of the weapon systems (needed for verification and validation of the simulations)
NGIC/Information Engineering	• Programming support • Interfaces *RADGUNS* with various computer systems • Develops graphical user interfaces and post-processing graphical programs • Consults on matters of programming practice, computer systems, transportability to different computers/operating systems, configuration control, etc.
NAWC, Weapons Division, Systems Effectiveness Branch (Survivability and Lethality Division, Aircraft Weapons Integration Department), China Lake, California	• Plans and organizes efforts for development of naval radar, gun, and environment models for *RADGUNS*
U.S. Strategic Command, U.S. STRATCOM/J534, Offutt AFB, NE Threat Evaluation Branch	• Plans and organizes efforts for development of *RADGUNS* models of countermeasures and counter countermeasures
JTCG/AS, Headquarters at Naval Air Systems Command, Washington, DC	• Oversees directions and plans for development of *RADGUNS* • Provides financial support for model/simulation development • Certifies *RADGUNS* as its standard AAA model • Distributes *RADGUNS* to users through SURVIAC

After an analysis of the AAA models available in DoD, the JTCG/AS chose *RADGUNS* as its standard gun model in August of 1987. Part of this analysis was documented in a report comparing *RADGUNS* with the standard AAA model at that time, P001. This report (Reference 4) was produced for the Survivability and Lethality Division of the Naval Weapons Center (now NAWC) at China Lake, which has been actively involved in supporting *RADGUNS* development and testing since that time. The JTCG/AS began making plans to support development of additional *RADGUNS* capabilities to enhance the AAA analysis capabilities of its tri-service members in 1988. Even though NGIC remains the most concentrated location of *RADGUNS* users, the number of users outside of NGIC has grown to more than ***80***.

2.3 VERSION DESCRIPTION AND CURRENT STATUS

The RADGUNS package of simulations if a collection of modules written in ANSI-77 FORTRAN. It consists of six main program modules, 315 subroutines (189 subroutines are unique, 4 occur 19 times in the GUNxxx modules and 10 occur 5 times in RADx), and 84 functions (42 unique functions, 1 occurs 19 times in the GUNxxx modules and 6 occur 5 times in RADx) that are contained in 34 files (see Table A-1). Combinations of 19 different gun and 5 radar types can be defined by the user to produce simulations of specific AAA threat systems. Program size totals are summarized in Table 2-4.

TABLE 2-4. *RADGUNS* v.2.0 Program Size Totals.

Number of Files	34
Number of Main Programs	6
Number of Subroutines	315
Number of Functions	84
Total Size (Kbytes)	1021
Total SLOC	18,173

Table 2-5 lists the applicable configurable items for RADGUNS v.2.0. Official RADGUNS-related documentation is prepared by the RAC Branch of NGIC in Charlottesville, Virginia. It is distributed with appropriate magnetic media containing the software by NGIC via SURVIAC. The following paragraphs briefly describe the manual contents.

TABLE 2-5. Configurable Items for *RADGUNS* v.2.0.

Description	Classification	Document No.	Date
Software magnetic media	SECRET/NOFORN		Feb 96
Volume 1. User Manual	UNCLASSIFIED	JTCG/AS 95-M-022	Feb 96
Volume 2. Supplement to User Manual	SECRET	JTCG/AS 95-M-023	Feb 96
Volume 3. Methodology & Design Manual	UNCLASSIFIED	JTCG/AS 95-M-024	Feb 96

Volume 1. User Manual

Section 1 of Volume 1 contains a brief overview of RADGUNS capabilities, an overview of the software, the coordinate systems used, and a model deficiency report form. Section 2 contains instructions for loading, compiling, and executing simulations on a variety of platforms. Also included in Section 2 are instructions for setting up parameter and jammer input files, a list of Input/Output file definitions, a list of weapon systems and targets modeled, and information on the RADGUI and CMEWS graphical user interfaces (GUIs), the IVIEW and ModelVU graphics programs, the RADGRAF plotting program, and a note on integration of *RADGUNS* into the Digital Integrated Modeling Environment (DIME). Section 3 contains detailed descriptions of the target, flight path, and hill models as well as a description of the scan-by-scan data output option and a table of unit conversions. Section 4 contains examples of both text and graphical outputs and Section 5 is dedicated to lethality/survivability analysis techniques.

Volume 2. Supplement to User Manual

Volume 2 is the classified supplement to the user manual. A list of new features in the current version is given in Section 1. Section 2 contains information on specific weapon configurations including radar and gun system data, and firing doctrine. Section 3 contains information on the RCS and presented/vulnerable area data files delivered with *RADGUNS*. The capabilities of some U.S. self-protection systems are listed in Section 4 as well as recommended ranges for realistic jammer parameter settings. Appendix A contains a list of files delivered with *RADGUNS* with a brief definition of each.

Volume 3. Design and Methodology Manual

Volume 3 contains a top-level design section as well as detailed information on the radar systems, optical sensors, gun systems, weapon system operators, end game calculations, environment, and electronic countermeasures/counter countermeasures. Each section contains information on the theoretical and mathematical algorithms employed in the software for reference by the analyst. The level of detail varies by section from general to very specific. Appendix A contains the solution of differential equations used in several routines. Appendix B, Dictionary of Principal Variables, lists some variables and constants used by the program with a short definition of each. Appendix C, Subroutine and Function Descriptions, contains a brief description of each subroutine or function, its calling sequence, security classification, size, location, calling environment, arguments, common blocks, and a discussion of some of the variables and formulas used in the implementation.

The extent to which these manuals address the information deemed necessary by the SMART Project to support the verification of a mature model is discussed in Section 5.

NGIC has made six fixes to Version 2.0 since its initial release to SURVIAC in February of 1996. SURVIAC has incorporated the changes into the distribution version and as of May 6, 1996, the model has not been shipped to any users. A fix list is included in Appendix G.

2.4 CHANGE PROCEDURES

Establishment and enforcement of guidelines for the development and distribution of a weapon system simulation program with DoD-wide use has been deemed essential to assure its continued credibility. The guidelines implemented and accepted for *RADGUNS* are as follows:

NGIC is the focal point for all *RADGUNS* planning and development, whether this development is performed at NGIC or elsewhere. Changes made to *RADGUNS* weapon system models by users can invalidate the models. However, users are encouraged to make enhancements to the models that do not affect the performance of the weapon system itself. Examples of this might be the addition of a new target flight path or a multiply-vulnerable area target model. Outside agency enhancements to *RADGUNS* deemed to be of benefit to other users should be forwarded to NGIC for integration into the distributed version of *RADGUNS*.

Version Numbers and Release Policy

NGIC releases a new version of *RADGUNS* to SURVIAC for distribution to users on an annual basis. Version numbers are of the form “m.n” (e.g., 2.0). The rules under which SURVIAC distributes *RADGUNS* are described in a Memorandum of Agreement (MOA) between NGIC and SURVIAC.

Users are expected to obtain new versions of *RADGUNS* from SURVIAC to remain current with the latest assessments of the weapon systems. Neither NGIC nor SURVIAC provides support for versions older than the current version. Secondary distribution of *RADGUNS* by users is prohibited.

A beta version is released to a limited number of *RADGUNS* users for beta (secondary) test 75 - 90 days prior to the release of a new version. Beta version numbers are of the form “m.nB” (e.g., 2.0B). Beta-users are not assigned specific testing tasks; rather, they are expected to use the model under typical conditions and report anomalies to the model manager. Errors may be corrected during the beta test period, but no new capabilities may be added. Beta site personnel are warned that beta versions may not be suitable for weapon analysis studies.

Sub-versions with enhancements for a specific customer are released only to the requesting customer. Sub-version numbers are of the form “m.n.p” (e.g., 2.0.1).

Fixes

NGIC sends code fixes to SURVIAC and beta sites approximately four times per year. New capabilities are not considered “fixes” and are not included in beta releases. SURVIAC incorporates fixes into the current version of *RADGUNS*. Simple fixes are sent to users on paper; complex fixes are sent on magnetic media.

Deficiencies

Users may submit reports of model problems or deficiencies directly to ASI, NGIC, or SURVIAC. A form is included in Volume 1 for this purpose. All such reports are acted upon and responded to by NGIC via fixes if appropriate or by direct communications with the user.

The SMART Project submits model deficiency reports (MDRs) directly to NGIC that describe discrepancies uncovered through verification and validation efforts along with recommendations for corrective actions.

A number of errors or deficiencies were discovered by users and during SMART V&V efforts on v.1.9. Table 2-6 gives a brief description of each deficiency, its implications, date reported, and current status. Deficiencies marked “approved” have been addressed in v.2.0, but reverification and revalidation have not yet been performed.

TABLE 2-6. Summary of User Reported Deficiencies on *RADGUNS* v.1.9.

MDR	Description	Implications for Use	Date	Status
95-01	PDET uses the maximum S/I for a scan instead of the average S/I for the number of pulses integrated.	May lead to early detections.	6/27/95	Pending
95-02	The Methodology and Design Manual does not describe the probability of detection model.	User cannot quantify detection results with this option.	6/27/95	Pending
95-03	Incorrect calculation of clutter patch areas for both pulse and beamwidth limited cases.	Power returned in pulse-limited case is half its correct value; one-fourth in beamwidth-limited case.	6/27/95	Approved
95-04	Numerical clutter model does not include beamwidth-limited case. Three-fourths conventional 3-dB one-way beamwidth incorrectly implemented.	Incorrect returns from clutter patches at large grazing angles with NUME option.	6/27/95	Approved
95-05	Incorrect variable description in Function CLUTG.	Documentation misleading.	6/27/95	Approved
95-06	Glint modeled as sinusoidal instead of random process.	Unknown.	6/27/95	Rejected
95-07	Sector search yields earlier detections than perfect cuing when using the probability of detection option.	Perfect cuing mode does not yield earliest detection.	8/8/95	Approved
95-08	Antenna pattern does not match intelligence for ZSU-23-4.	Narrower beamwidth may decrease tracking errors in some scenarios resulting in improved shooting performance.	8/17/95	Approved
95-09	Constants used in calculation of velocity of sound as a function of altitude should be changed.	Change does not significantly affect performance.	9/13/95	Approved
95-10	Beam nutation not included in calculation of antenna gain on incoming jammer signals (CONSCAN systems only).	Received jammer signals are slightly in error for CONSCAN radars.	9/20/95	Approved
95-11	57mm drag function does not match intelligence.	Trajectory of 57mm projectiles in error by (200m after 10 s TOF at 33.75 deg firing angle.	10/25/95	Approved

TABLE 2-6. Summary of User Reported Deficiencies on *RADGUNS* v.1.9. (Contd.)

MDR	Description	Implications for Use	Date	Status
	Support jammer implementation is too restrictive in terms of jammer flight path and RCS.	Only allows for a “welded” wingman support jamming platform.	8/9/94	Rejected
	Subroutine RGWO contains several false assumptions.	Assumptions are documented. No restrictions if used as intended.	8/9/94	Rejected
	RGWO should include hook and cover pulse options.	RGWO technique too restrictive.	8/9/94	Pending (More info needed)
	Multipath does not affect jammer signals.	One-way multipath effects not modeled.	8/9/94	Pending
	Jammer constants must be input for every technique. Jammer power not distributed among all jammers but rather input for each jammer.	Inconvenient for user.	8/9/94	Rejected
	DELTON calculation in subroutine SWEPTA appears to be incorrect.	Calculation is correct. No restrictions.	7/27/94	Rejected

Change Procedures

Decisions to make changes, add new capabilities, and release new versions are made by the model manager at NGIC. A Configuration Control Board (CCB) was formed in May of 1995 at the annual User Group Meeting and consists of members from each service, intel advisors, and contractors. No formal CM plan exists, however, plans to implement the preliminary CM Process Flowchart graphically depicted in Figure 2-1 were discussed at the user group meeting held in May of 1996. To date, the “No” or CCB branch of the first decision block has not been executed, and all development decisions have been made by the model manager.

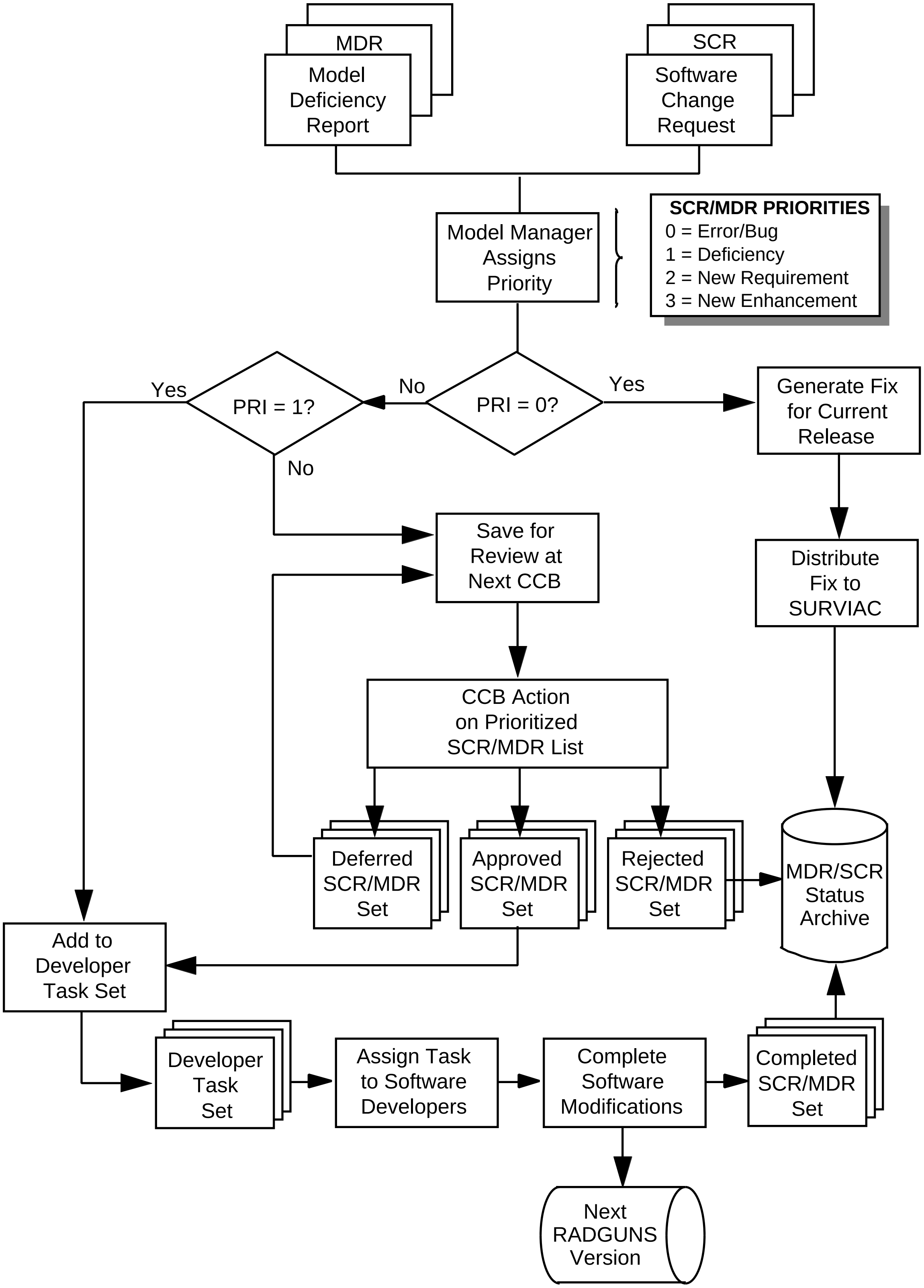

FIGURE 2-1. *RADGUNS* CM Process Flowchart.

2.5 USER SUPPORT FUNCTIONS

The Radar and Air Defense Division at NGIC examines and approves updated versions of *RADGUNS* before their release to SURVIAC for distribution. Distribution to users is further restricted by security regulations and the capability to maintain storage and computer systems approved for classified information.

SURVIAC validates user need and user security accreditation for the release of *RADGUNS* models. A written request from each user is required for the initial release, and NGIC approval must be given prior to the initial release of *RADGUNS* models to each DoD contractor. After NGIC approval, SURVIAC will ship *RADGUNS* to the Contracting Officer's Technical Representative (COTR) for distribution to the contractor.

ASI has been involved with the development and maintenance of *RADGUNS* for NGIC since 1987 and has provided user support with installation, setup, execution, training, and diagnosis of reported problems. Users may report problems to SURVIAC, NGIC, or directly to ASI, whereupon a determination is made as to whether the problem is user or computer system specific or a software bug that needs to be corrected. In the former case, adjustments to the documentation or specific user instructions may be necessary. In the latter case, the software is modified and the changes are distributed to the user community by SURVIAC. User problems often highlight areas of model deficiency or a lack of capability that feeds development efforts for the next version. The various elements involved in supporting this maintenance and development process are depicted graphically in Figure 2-2.

Training classes are held periodically at NGIC, often following user group meetings. Informal training classes may also be held at NGIC subject to the availability of personnel resources. Users requiring training on the usage of *RADGUNS* are advised to contact the Model Manager at NGIC.

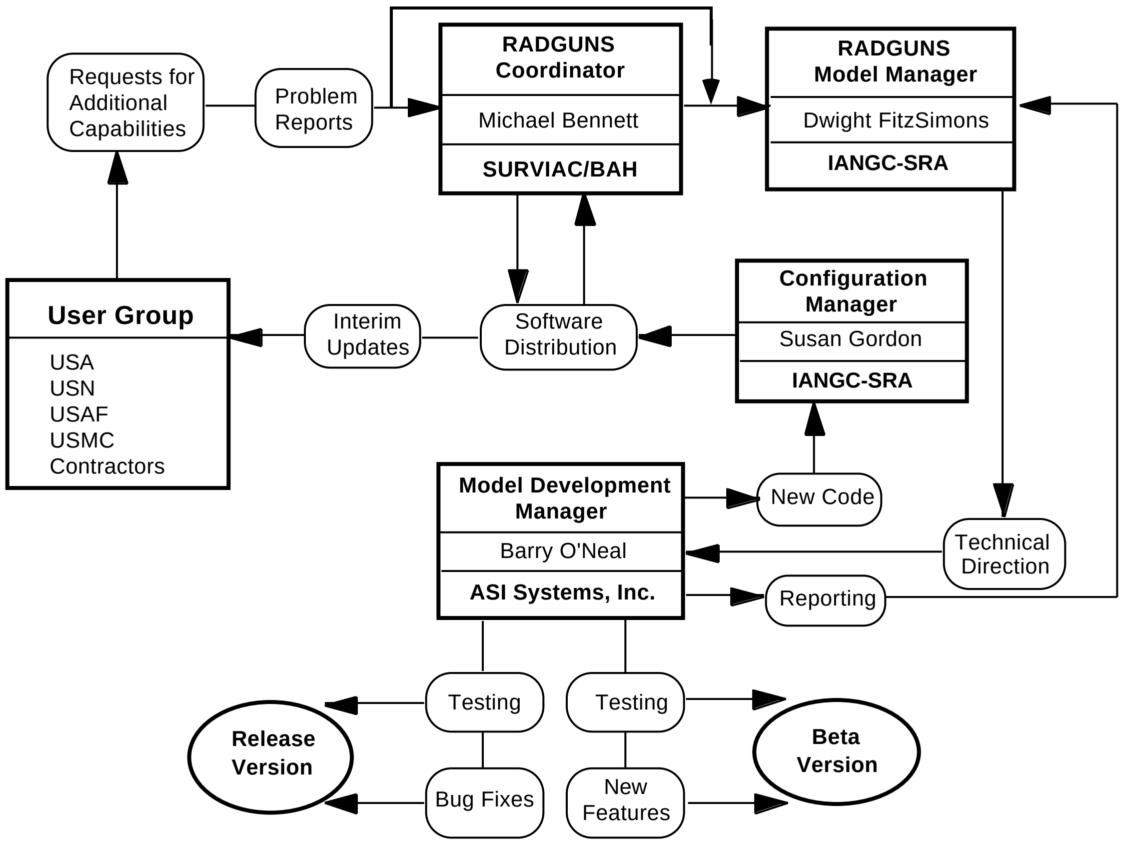

FIGURE 2-2. *RADGUNS* Maintenance and Development Elements.

2.6 IMPLICATIONS FOR MODEL USE

Based upon reports from the model developer and on VV&A questionnaire feedback and follow-up telephone conversations by personnel at ENTEK, Inc. on version 1.7, users find *RADGUNS* CM practices to be satisfactory. Most of the changes incorporated in model releases are in response to user requests for additional features and capabilities.

Users of the current version can expect support for questions and for problems from SURVIAC, ASI, and NGIC. Support for older versions is generally not available due to the amount of change between versions and the desire to maintain only the most current release. Past *RADGUNS* development has yielded a limited audit trail of model upgrades; however, NGIC has established adequate CM practices for recent and future *RADGUNS* upgrades.